REVIEW OF LITERATURE

A good understanding of techno-socio-economic feasibility of any production process is very essential to take any policy decision. Several production technologies with regard to inland and marine fisheries sectors are available in our country. The location specific resource oriented techno-economic feasibility of any production system ensures widespread adoption by fish farmers. Different researchers in various locations made several studies about the technical as well as economic viability of different production technologies. However these studies are either concentrating on economic or social or technical feasibility of the systems. Hence literature survey and their review was undertaken under the following major aspects.

2.1 Freshwater Aquaculture

In the total global inland fish production of 24.83 million tonnes in 1997, aquaculture contributed 17.13 million tonnes., where as mariculture contributed 11.14 million tonnes in total marine fish production of 97.17 million tonnes. At global level freshwater species shared 34 per cent by value and 42 per cent by quantity, where as that of India contribute 50 per cent in terms of value and 11 per cent by quantity (FAO, 1998).

Aquaculture in India can contribute 7 million tonnes of fish by 2,000 A.D. and can offer employment opportunities to 9 lakh people. To achieve this goal the development of all the aquacultural resources like freshwater ponds and tanks, reservoirs, brackishwaters, estuaries and the mariculture in coastal areas should receive urgent attention (Dwivedi, 1982).

Freshwater aquaculture has become an industrial enterprise in recent years with its immense possibilities of providing rich protein food, generating employment as also much required economic returns for any enterprise to establish. With the marine fish landings getting stabilized over the years and the inland capture fishery resources getting affected due to increasing pollution, dams and barrages in the river system, aquaculture sector is assuming greater importance in the present scenario. Apart from 1.00 million ha of ponds and tanks and 0.60 million ha of derelict water-
bodies ready for aquaculture, irrigation canals and reservoirs are also amenable for aquaculture. The growth rate of 5.80 percent in inland fisheries as compared to 3.7 percent in the fisheries sector as a whole is a pointer to the potentials of the sector. The gross domestic product from aquaculture is in the order of Rs.2,351.00 crores and freshwater aquaculture is expected to provide 4.5 million metric tonnes of fish/shell fish by the turn of the century (Tripathi, 1993).

The last two decades have witnessed immense growth in fish production from pond culture, especially freshwater, because of emphasis given for popularization of scientific technologies of fish-seed production and composite fish-culture in India and the efforts made for its development through Fish Farmer's Development Agencies. With all emphasis laid during the last two decades only about 19 per cent of the available resource in freshwater and 7 per cent in brackishwater could be brought so far under scientific fish culture. The remaining areas still either under traditional culture system or lying untapped. There is an urgent need for horizontal expansion by bringing in available ponds/tanks under scientific aquaculture. Available deep-water paddy fields can form additional resource (Sinha, 1999).

In comparison to crops and livestock, aquaculture needs little household labour. The studies revealed that introduction of improved aquaculture would enable labour to obtain a higher marginal productivity. Although the household labours are used mainly on crops, farm households would be able to allocate labour to aquaculture also without hampering other enterprises. Unlike agriculture crop aquaculture does not have no peak and lean season hence farmers can adjust fish stocking and harvesting to suit their resources (Ahmed and Rab, 1992).

Technological changes in aquaculture is considered important as the development of a new product, significant improvements in the characteristic or performance of an existing product and/or the development of improved technique of production. This distinction is useful for categorizing the kinds of developments that is required in aquaculture (Easley, 1992).

The development of aquaculture has been accelerating in recent years throughout India, particularly in the southern India. It has become the men profession for many small as well as big farmers in Andhra Pradesh, and 1.5 lakh ha of paddy fields had
been changed into fish farms in West Godavari district. Similarly coastal agricultural farmers of Tamilnadu had changed their lands either into fish farms or prawn farms (Rao, 1996).

The development witnessed in recent years in freshwater aquaculture led to the emergence of aquaculture in the inland water as an industry. With the technological inputs, scientific management and heavy investments, productivity of fish farming has increased tremendously. Inland pond productivity has increased best 600-800 kg $\text{ha}^{-1} \text{yr}^{-1}$ to 2 tones $\text{ha}^{-1} \text{yr}^{-1}$ and in some cases it is more than 10 tones. National inland fish production has touched the figure of 2.4 million tonnes, nearly 1.7 million coming from inland fish farming (Gopakumar, 1999).

Rural aquaculture is an important sub-sector that contributes significantly to the national food security, family nutrition, and rural employment especially in the remote and disadvantaged areas. About 30% of the animal protein intake by Vietnamese people come from fish. Small holders of aquaculture contribute over 70 per cent to the national aquaculture production. It is a potential resource for improving household food security and supplementing family income of the rural poor communities (Luu, 1999).

Rural aquaculture attains to the farming of aquatic organisms by small scale farming of households or communities, usually by extension or semi-intensive, low cost production technology appropriate to their resource base. The main objectives of rural aquaculture are to ensure household food security and to generate income from surplus production system (De and Saha, 1999).

Fish production from village tanks and ponds can be increased through scientific farming which will help to improve the socio-economic condition of the rural population by providing them employment opportunities in aquaculture. Proper utilization of available tanks and ponds for fish culture with the application of a package of inputs is likely to increase the production manifold (Rout and Tripathi, 1985).

Amblypharyngodon mola can be successfully cultured in small seasonal ponds, which can play important role in ensuring greater diet diversity, and increased
intake of vitamin A, calcium and other essential nutrients among rural populations. An average production of 0.34 tons ha\(^{-1}\) in seven months in mola ponds and 0.44 tons ha\(^{-1}\) in seven months in the mixed ponds were achieved in some village ponds of Bangladesh (Roos et al., 1999).

Fish production either in fresh or brackishwater culture systems depends upon the quantities of inputs such as seed, feed and fertilizers. Quantitative relationships between inputs and output in many cases are not linear. It is not possible to produce unlimited quantities of fish from a given area of pond even if seed, feed and fertilizers are available in unlimited quantities. There are biological limitations beyond which one can not augment production from a given area of pond even with modern tools of aquaculture (Ranadhirand Tripathi, 1991).

The most important centrally sponsored agency for aquaculture extension service is the Fish Farmers Development Agency (FFDA) which is a district level organization for the development of freshwater aquaculture. To date, 423 FFDA's have been working throughout the country covering a water area of 0.359 million ha of ponds/tanks under aquaculture with average production of about 2,000 kg ha\(^{-1}\) yr\(^{-1}\) (Kumar, 1996).

2.1.1 Polyculture and monoculture

In an ecosystem such as fishpond there exist various positions which can be filled by different species. By combining different species in the same pond the total fish production can be raised to a higher level than which would be possible with only one species. The term polyculture can also be used to describe the integrated farming of fish with other animals. In monoculture only one species of fish is kept in the pond. This is used where very high levels of production are aimed at, with the use of supplementary feeds (Swift, 1985).

Poly-culture has been the most popular in China, India, U.S.S.R. and Israel. Bighead carp, grass carp, common and grey mullet were stocked with milkfish, Tilapia, sea perch in Taiwan province of China and Hongkong. Common carp, crucian carp and shrimp formed the main component candidate species for culture in Japan. Polyculture in Yogoslavia utilizes common carp as the primary species
supplemented by tench, catfish, pike-perch and pike. A common carp tilapia mixed culture was found to be very successful in Israel (Sinha, 1976).

Lin (1955) reported the details of poly-culture as practiced with several species of carp in China. The use of grass carp, together with tawes (Puntius gonionotus) and Oreochromis mossambicus appeared to be very successful than the traditional Chinese carp culture.

Culture of single species in a given culture unit, regardless of whether it is a pond, a raceway, a tank, a cage or other type of culture chamber is known as Mono-culture (Stickney, 1979). In pond mono-culture the animal being reared usually fails to utilize all positions of environment. Polyculture, the rearing of two or more species in each culture unit, enjoys wide popularity throughout much of the world (Bardach et al., 1972).

Polyculture is commonly practised in pond where several fish species are reared together, creating multi-output production structure. Sharma et al. (1999) applied a non-parametric data envelopment analysis (DEA) technique for multiple outputs to measure economic efficiency and its technical and allocative components for Chinese polyculture fish farms and to derive optimum stocking densities for different fish species. Smaller farms from developed regions were found to be relatively more efficient technically and economically.

Cage culture of Catla catla has been carried out successfully in a freshwater tank. Rearing of fingerlings to table size at a stocking density of 1.26 lakh ha\(^{-1}\), 1.41 kg\(^{-1}\)m\(^{-2}\)month\(^{-1}\) and 1.31 kg\(^{-1}\)m\(^{-2}\)month\(^{-1}\) was achieved (Govind et al., 1988).

Carp polyculture has gained much importance all over the world because it contribute to the extent of 90 per cent of total aquaculture production Planktophagous, herbivorous, fast growing, non-predatory species of fish are generally preferred for culture in freshwater ponds because they efficiently convert organic matter into fish flesh and consequently give high yields (Michael, 1988).
During the late fifties exotic species of carps, viz., grass carp, silver carp and common carp, were introduced into India. Extensive research on their compatibility in mixed culture was conducted at the pond culture division of the Central Inland Fisheries Research Institute (CIFRI), Cuttack (Lakshmanan et al., 1971).

The compatible combination of Indian major carp and exotic carp which termed as composite fish culture is quite distinct from Indian polyculture of carps where only Indian major carp are reared together. The fish production increased much more when the pond was stocked with 6 species combination, viz. catla, rohu, mrigal, silver carp, grass carp and common carp compared to the production obtained either with rohu, catla and mrigal combination or silver carp, grass carp and common carp combination. This high yielding combination of 6 species of carps is termed as Composite Fish Culture. On the basis of growth performance of different species, modifications are made in stocking density, species ratio, fertilization and supplementary feeding programmes to improve the growth rates of the fishes and thus to achieve better production (Sinha and Gupta, 1975).

In addition to the six species of carps, other fishes comprising a feather back (Notopterus chitala) and three catfishes (Ompok bimaculatus, Mystus seenghala and Pangasius pangasius) were included to feed on minnows, insects, shrimps and molluscs. With the extension of composite fish culture to larger ponds of about 2 ha, a production of about 4,000 kg ha\(^{-1}\) yr\(^{-1}\) was obtained in West Bengal (Sinha et al., 1973).

The composite fish culture technology innovated and standardized during seventies at Central Inland Fisheries Research Institute (Chakraborty et al., 1974) was successfully demonstrated throughout the country with an average production potential of 3,000 kg ha\(^{-1}\) yr\(^{-2}\) and formed a major aquaculture system in freshwater of West Bengal and neighboring states (Bhaumik and Saha, 1998).

Carp poly-culture is the most prevalent system among freshwater pisciculturist in the country, with large varieties of fish species, stocking densities, water management, feeding practices etc. depending on the resource availability and local
demands. CICFRI developed a package of practices of carp culture with an average production potential of 4,000 kg ha\(^{-1}\) yr\(^{-1}\). Composite fish culture aims of fuller utilization of pond productivity at different ecological niches by culturing together fast growing six compatible species of complementary feeding habits. The ratio and number of different species is suitably regulated in an environment free of weeds and harmful fishes under hygienic condition with health monitoring as and when required (Sinha, 1990).

Most of the fish harvested from farmed and non-farmed water bodies, consist of both stocked and wild fish and the average fish yield in Bangladesh was only about 550 kg ha\(^{-1}\) yr\(^{-1}\) (Ahmed, 1992). New aquaculture systems that combine culture of Indian major carps with common carp (\textit{Cyprinus carpio}) and Chinese carps and the short cycle culture of species such as tilapia (\textit{Oreochromis niloticus}) and silver barb (\textit{Puntius gonionotus}) could increase productivity by as much as three times (Gupta et al., 1992).

Dalai and Das (1992) reported average low fish production i.e. 800 kg ha\(^{-1}\) yr\(^{-1}\) from extensive fish culture in selected blocks of Ganjam district of Orissa. The study revealed which could be attributed to lack of proper management practices. The farmers were found to use inferior quality and low quantity of different inputs indicating lack of awareness among farmers about aquaculture practices.

Shankar et al. (1998) studied on the role of substrates based microbial biofirm in the production of \textit{Cyprinus carpio} and \textit{Labeo rohita} using an easily available and bio-degradable agricultural waste product (Sugarcane bagasse) as substrate. Results indicated the potential for increasing fish production at cost by adding easily available and bio-degradable agricultural substrates in to the ponds. Development of viable, low cost technologies and their application to current farming practices will help to increase the area under aquaculture as well as its yield.

A yield gap and constraints in inland fish culture study made by Suresh et al. (1988) revealed that the presence of predators and weed fishes, poor quality and inadequate application of inputs as the major production constraints.
2.1.2 Integrated aquaculture

The integrated approach of development of agriculture, animal husbandry and fish farming is essential for an overall rural development, since it would result in farm produce diversification, increased cash income, improved quality and quantity of food produced for home consumption, and exploitation of unutilized resources available to small farmers (Sinha, 1978).

The nutritional potential of aquatic resources is very important in developing countries. To realize this potential, integrated research and management for sustainable water resource use are needed. An interdisciplinary communication and research collaboration of various disciplines of limnology, hydrology, aquaculture, fisheries ecology and management and pollution ecology is essential for sustainable use of inland aquatic resources (Mitchell and DeSilva, 1992).

New way of farming that regenerates environment and increase household purchasing power must be designed, tested and put into operation by large number of farmers. Important components of such systems both for environmental and economic objectives, will be biological diversification and nutrient recycling. The integration of aquaculture and forestry into agriculture based farms provides an appropriate starting point on the design of regenerative farming systems (Lightfoot, 1990).

Carp polyculture is well integrated with other farming systems like poultry, piggery, duckery and horticulture as also with paddy cultivation. Around 2 cows, 40 sheeps, 250 ducks, 500 poultry birds, 40 pigs can sustain fish production levels to the extent of 3-6 tonnes ha\(^{-1}\) yr\(^{-1}\). Integrated system provides a high risk aquaculture but the yields are also high in the order of 3000 kg ha\(^{-1}\) yr\(^{-1}\) in cattle-based, 3,500 kg ha\(^{-1}\) yr\(^{-1}\) in duck based, 4,000 kg ha\(^{-1}\) yr\(^{-1}\) in poultry based and 6,000 kg ha\(^{-1}\) yr\(^{-1}\) in pig based system (Tripathi, 1993).

Agriculture, animal husbandry and fish farming were viewed as both complementary and supplementary to the ecological niche. An extensive type of paddy-cum-shrimp culture is a unique practice in certain parts of India. Fish-culture in paddy fields was extensive and well developed in Indonesia (Sinha, 1976). A three
way rotation of fish, soyabees and rice is being tried with considerable success by some farmers in Arkanses, U.S.A. (Pillay, 1973).

Paddy-cum-fish culture in India had been described in detail by Hora (1951), Chacko and Ganapati (1952), Iyengar (1953), Alikunhi (1960), Tripathi (1963), etc.

The village resources are best suited for integrated system of fish culture. The integrated systems available are paddy-cum-fish, poultry-cum-fish, cattle-cum-fish and pig-cum-fish farming. Some of the systems can be adopted either in single or in combination. Paddy-cum-fish culture is one of the most appropriate technologies for rural development (Ranadhir, 1998).

Integrated rice-fish culture is practiced within rice areas protected from excess flooding by dikes. A wide variety of fish species have been cultured, including common carp (Cyprinus carpio); Indian major carps such as rohu (Labeo rohita), mrigal (Cirrhinus mrigala) and catla (Catla catla); Chinese carps such as silver carp (Hypophthalmichthys molitrix), and occasionally grass carp (Ctenopharyngodon idella); Nile Tilapia (Oreochromis niloticus) and silver barb (Puntius gonionotus) (Gupta et al., 1998). Reported fish production figures under paddy-cum-fish culture vary widely, ranging from under 100 kg ha\(^{-1}\) to over 2000 kg ha\(^{-1}\), depending on the intensity of the system (Lightfoot \textit{et al.}, 1992).

Our country has a resource of 2.3 million ha of deepwater rice plots in the freshwater sector, which can be exploited through rice-fish culture. States with heavy monsoon precipitation, particularly West Bengal, Assam, Tripura, Manipur, Orissa, parts of Bihar in the eastern part of the country, some parts of Andhra Pradesh, Karnataka and Kerala in the south have good potential for further development of rice-fish farming. The deep water rice fields, retaining around 50 cm of water or above during monsoon months, are ideal for fish integration. In Assam many parts of the old fortresses constructed by tribal chiefs of the states are considered most suitable for rice-fish farming. The 37 ha Jangal Balahu Garh fortress in Nagaon district offers a ready-made site for rice-fish farming. There are other noflood prone areas in Goalpara.
and Dhubri districts of the state which could also be developed for rice-fish culture (Ghosh, 1992).

Paddy-cum-fish culture in freshwater paddy fields has not been popular although considerable potentiality exist in West Bengal, Assam, Bihar, Orissa and Andhra Pradesh and technology in this regard is available (Ghosh et al., 1985).

Paddy cultivation in the North Eastern states continues to be on the traditional pattern, providing a subsistence level of income only. Added to this, geographical isolation and high demand of fish has rendered paddy-cum-fish culture as a highly cost effective and financially viable agrarian practice. Ghosh and Pathak (1988), studied economics of paddy-cum-fish culture in North eastern states in different situations like monocropped areas in the low hills, the monocropped areas in the plains of Assam, Manipur and Tripura and irrigated double cropped areas of Manipur and Assam. The additional production prospects from fish in the three situations vary from 200 kg ha\(^{-1}\) crop\(^{-1}\) to 1000 kg ha\(^{-1}\) crop\(^{-1}\) at a negligible extra cost.

Paddy-cum-fish culture is practiced in some appreciable extent only in Nagaland among Northeastern state. There are some traditional practices of growing fish in the paddy fields in certain other areas like Juria block of Nagaon district (Assam) and the hill tracts of Ukhrul district (Manipur). But these culture practices are low yielding and mostly subsistence in nature. The Agricultural Finance Corporation / CIFRI study has identified enormous potential for developing paddy-cum-fish culture in the north-east. Out of the potential 45,000 ha, only 2,7780 ha were developed till 1991 (Sugunan, 1998).

Bayan et al. (1996), observed that the practice of collection of various fish species from the waterlogged rice fields during rainy season is common among the rice farmers of Barpeta district of Assam. Though the true culture fishery was hardly observed some farmers stocked their paddy field with fry and fingerlings of carps and obtained a fish production of 300 kg ha\(^{-1}\) season\(^{-1}\) This study revealed that less productive rice areas (1-1.8 tonnes of rice) where water logged for 3-7 months may be used for the production of fishes with rice.
The state fisheries department of West Bengal, undertook nursery rearing of carps in rice fields where carp fry (19-64 mm) were stocked at 1,457 ha\(^{-1}\) and raised up to 127-135 mm size in three to four months to get production of 112 kg ha\(^{-1}\) (Hora, 1951).

Experiments on double cropping of paddy by creating facilities of storing water in a part of rice field through its conversion in to a trench, canal or a small pond for fish farming as an additional component resulted in a total production of 5,500 kg ha\(^{-1}\) of paddy and 700 kg ha\(^{-1}\) of quality fish (Ghosh, 1979).

Delacruz (1992) reported that fish culture was practised in Cordillera Administrative Region, rainfed mountainous area in the Northern Philippines, during rainy months (August-December) followed by concurrent rice-fish-culture from January to August. The major species cultured were Nile Tilapia (Oreochromis niloticus) and common carp where 250-200 kg ha\(^{-1}\) of fish production was obtained. Rice mono-culture without fertilizers (one crop per year) yielded an average 2.38 tonnes ha\(^{-1}\) as against 3.13 tonnes ha\(^{-1}\) with inorganic fertilizer plus 0.38 tonnes ha\(^{-1}\) of fish (two crops) for the experimental pattern.

Ghosh (1990), reported that an experimental rice-cum-paddy fish culture was carried out in west Bengal in 1.02 ha paddy plot with 0.27 ha perimeter canal of 6 m width and 1.2 m depth where carp fingerlings were stocked at the rate of 6,000 fingerlings ha\(^{-1}\) maintaining the species ratio of rohu 30 : catla 40 : mrigal 30. This experimental culture practice showed a production of 1,200 kg ha\(^{-1}\) kharif paddy and 4,300 kg ha\(^{-1}\) rabi paddy besides 700 kg fish ha\(^{-1}\) per 10 months.

Felix et al. (1992) reported that under the integration of paddy and fish two crops of paddy and a single crop of fish was raised. Rohu, catla, mrigal, common carp and minor carp were stocked at the rate of 4,000-6,000 ha\(^{-1}\) and harvested after attaining average weight of 400-500 gm per fish at the end of kharif season. Annual turnover of Rs.34,550.00 was achieved by annual investment of Rs.11,397.00 with rice production of 6 tones and fish production of 1 tonnes.
Stocking of hatchery produced fingerlings in semi deepwater rice fields in Mekong Delta region of Vietnam resulted in production of fish from 99 to 730 kg ha\(^{-1}\). In most cases fish yields are below 300 kg ha\(^{-1}\) for a rearing period of 6-9 months. Typical fish species in this system are silver barb (*Puntius gonionotus*), common carp (*Cyprinus carpio*) and tilapia (*Oreochromis niloticus*). Reasons for the low farm input include a combination of technological and socio-economic factors and natural hazards. Pie fish profitability was also affected by low market price and high production cost (Nhan et al. 1997).

Household scale integrated farming in Vietnam combines three diverse farming components - the vegetable or fruit trees garden, fish/shrimp pond and livestock pen practice is a popular farming practice. This system is based on optimum use of byproducts and wastes through recycling in aquaculture ponds. In such a system, the aquaculture component contributes about 30-70 per cent to the total income from the household farming system. Fish is produced primarily for family consumption; the surplus is sold. Pond water is used for live stock and for irrigating the garden. From time to time, the bottom sediment is dredged and used as organic fertilizer for vegetables and fruit crops (Luu, 1999).

Mazumder and Lorenzen (1999) studied to explore recent changes in the availability of small native species (SNS) in relation to agro-ecology and related issues as the small native species of fish have played important role in the livelihood of rural people in Bangladesh. Poor people have gained from the intensification of agriculture in terms of rice consumption but they have lost in terms of reduced access to fish and other animal products. The integration of small native species into aquaculture systems may be an effective method of increasing their availability to the local population and to conserve the biological diversity that they represent.

The system of integrating fish culture with live stock rearing is rather developed in China, Malaysia, Hungary and Germany. In some of these countries fish farming is integrated with poultry rearing or pig farming (Woynarovich, 1979). In India experiments of integration of fish culture with piggery were initiated at CICFRI, Barrackpore in the year 1979 (Sharma et al., 1979). Pig keeping in India is associated with weaker sections of the society and tribals who maintain indigenous breeds of
non-descript types. Pigs are fed and/or allowed to graze on pond banks, slopes and edges, the wastes either automatically flowing down into the pond or else drying up and getting converted into a manure which is washed into the pond during rain (Tripathi, 1993).

In pig-cum fish culture 60 per cent of the area is used for fish ponds while 10 per cent is used for raising grass and the remaining 30 per cent for piggery and duckery, besides canals. Pigsties are erected on the pond embankments and each pig house is divided into several compartments of 2.5 x 2.5 m² size. About 5-25 pigs of six weeks old per hectare of farm area reared depending on the type of integration (Joseph, 1993).

Daily application of fresh, raw wastes collected from pigsties and placed in heaps in the four corners of a 0.1 ha pond resulted in a production of 7,300 kg ha⁻¹ yr⁻¹. It was estimated that 35-40 pigs would void 20,000 kg ha⁻¹ yr⁻¹ in one year and hence could be safely reared for fertilizing a 1 ha pond (Jhingran and Sharma, 1979).

Experience has also shown that approximately 3-5 kg of carp can be produced by using 100 kg of pig manure as a fertilizer (Woynarovich, 1979). In the Central African Republic, pig raising in conjunction with fish farming has more than tripled farmer's earnings and significantly improved fish production. Pig-cum-fish culture influenced in increasing farmer's earnings by more than three times with a significant improvement in fish production (Pillay, 1973).

Even though poultry-fish farming has not yet been widely practiced integrated fish farming as pig-fish or duck-fish, seems to be more advisable due to the high nutritive value of poultry droppings. The poultry droppings maintain primary production levels above 300 mg cm⁻¹ cm⁻¹ hr⁻¹. A mixed culture of milk fish (fingerlings), Tilapia (fingerling) and shrimp (juveniles) were carried out at a stocking density of 200, 1,500 and 5,000 respectively in a 0.1 ha pond where a poultry house of 4x8 m size stocked with 90 chicks of 3 weeks old was installed. Two chicks crop were harvested along with one fish crop during 90 days culture period (Banerjee et al., 1989).
Ayyappan (1999), described a new floating shelter system for duck-cum-fish culture in an integrated farm. This system prevents the predation of fishes by the ducks and movement of the floating unit throughout the ponds makes uniform distribution of duck droppings. The recommended shelter area for each duck is 0.5-1 m² and spacing is 1 duck /2-4 m². He also described a new system of poultry-cum-fish culture that overcomes collection of wastes and adding them to the pond. This system prevents eutrophication as bird wastes are no longer accumulated at one site.

2.2 Costs and Earnings of Various Fish Farming Practices

Economics is concerned primarily with the study of problems associated with the production and distribution of economic goods and services. Economics deals with choices between alternatives. Problems of choice arise only when resources are scarce and alternative uses can be made of them.

The cost of anything is the expenditure involved to produce it. The revenue received from the next best use is referred to as the opportunity cost. Total cost of production is often divided into variable costs and fixed costs. Variable costs include money payments for fertilizers, fingerlings, chemicals, feed and payments for labour. Fixed costs are those costs incurred even if there is no production. The two normal fixed costs are depreciation and interest for the initial investment. Variable costs are related to the quantity of output produced. The total fixed costs (TFC) curve is parallel to the horizontal axis. This means that cost is same for the production period. The total variable cost (TVC) curve begins from the origin and increases at an increasing rate and then at a decreasing rate. The total cost (TC) is the sum of the TVC and TFC. Thus the TC curve originates at the point where TFC curve meets the vertical axis then runs parallel to TVC, because fixed costs don't vary in the-short run (Sundharam and Vaish, 1973).

The relationship between the cost function and output may be better studied by examination of marginal cost curves. Marginal cost is the additional cost necessary to produce one more unit of output. Marginal costs depend on the nature of the production function and the unit costs of the variable inputs.
The total costs in inland fishery consist of variable and fixed costs. The variable costs are expenditure made toward seed, fertilizers, feed, chemicals to control pest and diseases, fuel and electricity charges, annual pond preparation costs, wages to hired labour, interest on working capital and imputed value of family labour. The fixed costs are insurance charges, depreciation cost annuity value of pond construction cost and interest on fixed capital.

There are not many studies on aquaculture economics in the country. Ranadhir (1976) first reported the costs and earnings of traditional fish culture operations. Tripathi and Ranadhir (1981) presented an economic analysis of composite carp culture technology. Recently, based on 156 case studies, a model on composite carp culture has been developed with input use and output elasticity (Ranadhir, 1989), which explains 84% variations in the output. The model indicates feed to be the most important variable with high output elasticity.

Experimentation with various methods of data collection and analysis is a necessary step for assessing economic health of the fishery. Smith et al. (1983) conducted an investigation to collect costs and earnings and price data from sample respondents in the harvesting and marketing sectors from San Magual Bay.

Cost of production is the most important factor for understanding the profitability of an aquaculture enterprise. Sinha (1978) worked out cost of production at Rs.2.80 to produce fish at the rate of 6537kg ha\(^{-1}\) yr\(^{-1}\) from a pond area of 0.25 ha in Assam.

A fish farmer has to plan very carefully in advance about his expected expenditure on the inputs involved so as to reduce his cost of production on land, labour and technological aspects. In addition to the variable costs, fixed costs such as insurance, interest on capital, taxes have to be brought down for earning high profits (Rao, 1996).

Easley (1992) stated that reduction in the production cost may be possible through genetic and biological manipulation. The economic effects of such
improvements can be analysed at both the firm and industry levels. At the firm levels by improving food conversion, the cost of growing an additional fish can be reduced.

The size, shape and depth of the pond and the clearing work required also affect the cost of construction. Generally larger the pond size the greater the efficiency of land and water utilisation and lower the construction costs. On the other hand the smaller the pond size the greater the convenience of pond management and lower the earth work maintenance (Tang, 1979).

The profitability of fish culture in the ponds depends mostly on the cost of production and market price of the fish besides the yield. High profitability can be achieved by better biological and technological management of the ponds. Padmavathi and Anjaneyulu (1992) studied the cost of inputs, production and earnings in two successive crops in three ponds with different managerial practices in Krishna district, Andhra Pradesh. The study revealed that fish yield, operational costs and returns varied among the ponds and also between successive crops.

Leopold (1378), revealed that bigger the individual size of stocking material lower the cost of production per unit of marketable fish and higher the profit. Fish kept in one pond for longer period to produce larger size would result in higher cost per unit of fish harvested. It would not be economically feasible to produce larger sizes if the increased cost of feed could not be offset by the increased unit price of a larger fish.

An analysis of the production costs was made on the basis of the data collected from different parts of India, under the All India Co-ordinated Research Project on Composite Fish Culture to know the potentiality of the pond for fish production and cost involved in the major inputs such as feed, fertilizers and fingerlings required. The improved composite fish culture could be adopted in existing old ponds with an expenditure of Rs. 1,000.00 ha\(^{-1}\) for every 10 years. The cost for certain implements like nets could be considered as Rs.1,500.00 for five years; annual developmental cost for net will be about Rs.400.00 (Sinha, 1976).
The cost of feed can be reduced by improving the conversion ratio or by lowering the unit price of feed or by combining these two factors. The economic principle of feeding is that the amount of feed should be at a level where the additional cost of feed equals its additional revenue. Amounts above this level would be a waste from an economic point of view. Using either organic or any combination of organic and inorganic fertilizers might reduce the total cost of fertilizer. The amount of fertilizer applied should not cost more than the additional revenue it produces, and the least cost combination of fertilizers occurs when the marginal rate of substitution equals the inverse ratio of the price of fertilizers (Shang, 1981).

Feed and/or fertilizer comprise more than 50% of the total cost of production (Rabanal and Shang, 1979; Wattanuchariya and Panayotau, 1982, Shang, 1981). Cost of feed per unit of fish production \( (C_f) \) depends primarily on two elements: the conversion ratio of fish to flesh \( R \) and the unit price of feed \( (P_f) \). Shang (1981) expressed this as \( C_f = RP_f \).

In traditional fish culture, the important aspects of pond preparation, manuring and fertilization are almost absent except that at times organic manure is supplied. But in composite fish culture besides selecting suitable compatible species and their ratio, feeding of fish with supplementary feeds and fertilization of ponds are done. Thus all these necessitate and justify a full time occupation. A fish farmer himself with the help of one fisherman should be able to carry out feeding and fertilization programme and the watch ward of the fish pond/ farm. For a 2 ha unit a skilled fish farmer along with two fishermen and two watchmen would be needed (Sinha and Ramachandran, 1998). Small and marginal aquaculture farmers who are having nearly 200 days of excess labour can fruitfully utilize their excess manpower towards culture of fishes which may raise their income level above Rs.8000.00 which is taken as the poverty line (Ranadhir, 1997).

An economic analysis of polyculture of Indian and exotic carps revealed that a net profit of Rs.22,100.00 could be obtained by investing a total amount of Rs.37,900.00 where percentage of return on variable cost was 58.30. This analysis sowed cost of production of one kilogram fish at Rs.9.47 (Sinha, 1990).
An analysis worked out by Ranadhir and Tripathi (1991) revealed that an additional production of 4,847 kg ha\(^{-1}\) of exotic carp was obtained by foregoing a production of 1,378 kg of IMC at Killa fish farm in Cuttack. The farmer has to incur an additional cost of Rs.27,348.00 ha\(^{-1}\) besides a loss in income of Rs.27,560.00 ha\(^{-1}\) in not producing Indian major carps to the production capacity at current price levels. The additional cost and loss was more than compensated by production of additional exotic carps. The production of exotic carps could offer an alternative to the lower middle class and poorer sections of the society in view of the high cost of IMC.

Suresh et al. (1992) evaluated the costs and returns from composite fish culture in Madurai-North and Melur Taluks of Madurai district. The cost of stocking and harvesting associated for a major share followed by feeding and fertilization. The total cost of production per ha was Rs.2,930.00 in Madurai-north Taluk. The average cost of production per kg of fish was Rs.5.60 in Madurai-north Taluk and Rs.4.50 in Melur Taluk. Net return per ha was Rs.2,863.00 and Rs.818.00 in Melur Taluk and Madurai-north Taluk respectively. Output input ratio indicated that for every rupee invested in fish culture, returns of Rs.1.27 and Rs.1.74 were found in Madurai and Melur Taluk respectively. Total cost function showed that on increase in pond size by one ha would increase total cost by Rs.395.00 and every additional kilogram of fish produced would involve a marginal cost of Rs.3.40. Variable cost function showed that an increase in fish production by one kilogram would increase total-variable cost by Rs.3.10.

Dalai and Das (1992) studied economic analysis of extensive fish culture in selected blocks of Ganjam district, Orissa where the expenditure on lime, manure and fertilizer ranged from Rs.295.00 to Rs.3,500.00 ha\(^{-1}\). There was a significant correlation (P < 0.05) between cost of fertilizers and manures with total fish production. The regression equation developed was \(Y = 604.105 + 0.282 \times X1\) \((r^2 = 0.414)\). The expenditure on feed was Rs.250.00 to Rs.1,200.00 ha\(^{-1}\) yr\(^{-1}\) Significant correlation was found between cost of feed and fish production and regression equation developed was \(Y = 508.148 + 0.792 \times X2\) \((r^2 = 0.495)\). The labour cost ranged from Rs.50.00 to Rs.500.00. A significant of correlation between cost of labour and fish production was found and regression equation was developed as \(Y = 547.172 + 1.439 \times X4\) \((r^2 = 0.275)\). Total cost indicated the degree of input used and influenced...
the yield. Total cost ranged from Rs.900.00 to Rs. 16,500.00 which showed significant correlation between total cost and fish production. The regression equation developed was - \( Y = 327.768 + 0.0652 \times X \) \( r^2 = 0.489 \).

Rao and Raju (1998) studied the cost structure of a freshwater fish farm of 8.93 ha size. The variable costs shared 86 per cent of total costs whereas fixed costs shared 14 per cent. The total variable cost ha\(^{-1}\) of freshwater fish culture on an average came to Rs.35,710.00 from the sampled farms on an average. The total fixed costs accounted to Rs.5,747.00 ha\(^{-1}\) of which annuity value which was the spread out value of initial pond construction costs over its life period, shared 4.25 per cent of total cost i.e. 1,760.00 ha\(^{-1}\). Depreciation cost was reported to be Rs.692.00 ha\(^{-1}\) i.e. 2 per cent of total cost. The supervision charges, watch and ward came to Rs.1,587.00 i.e. 3.82 per cent ha\(^{-1}\). On an average the total costs ha\(^{-1}\) of freshwater fish culture was Rs.41,457.00 on an average and the productivity under freshwater fish culture was 3,903 kg. Total returns was reported was Rs.82,880.74 as against the total costs of Rs.41,457.00.00.

Ranadhir (1998) reported minimum production of 500 kg of 700-750 gm individual size fish in a year's time with a gross income of Rs.7,500.00 by investing Rs.3,008.00 from a 0.2 ha pond size. Starting with the simplest technology where ponds are prepared, manured and stocked, the farmers can easily leap the benefits to the tune of Rs.22500.00 ha\(^{-1}\) yr\(^{-1}\). In case of an intermediate level of input application with a total cost of Rs.76,000.00 a net profit of Rs.44,000.00 ha\(^{-1}\) was obtained where average gross yield was 6 tonnes ha\(^{-1}\) and cost of production was Rs. 12.65 kg\(^{-1}\). A net profit of Rs.76,000.00 was obtained in a high level of input technology culture practice where total cost was Rs.1.29 lakh ha\(^{-1}\) and average gross yield was 10 tonnes. The stocking density of Indian and exotic carps followed in the low input, intermediate input and high level of input technology was 5,000 (only IMC), 3,500 and 6,000 numbers (IMC and exotic carps) respectively.

Singh et al. (1995) worked out the economics of fish production in Hasanpur block of Bihar where average fish production per hectare was found to be 1,477 kg. While the productivity was higher on medium ponds i.e. 1,675 kg ha\(^{-1}\), it was much
less on small ponds i.e. 952 kg ha\(^{-1}\). The cost of production of fish was Rs. 17.84 kg\(^{-1}\) though on higher side yielding a net income of Rs. 14.52 kg\(^{-1}\). Return on investment per rupee in fish production was worked out to be 123.00 per cent. The study revealed that fish farmers were using indigenous species of fishes and practicing traditional method of fish culture, generally on rented public ponds. For these types of ponds the average cost of fish production per hectare was Rs.17,490.00 accounting for 67.41 per cent variable costs and 32.59 per cent fixed costs.

Ghosh et al. (1985) worked out the capital and operating cost and return on the basis of one ha in paddy-cum-fish culture system developed by CIFRI and this revealed that a net profit of Rs.3,629.00 could be achieved by an annual investment of Rs.18,140.70.

The operational economics of integrated system shows a far higher return than paddy cultivation. At an operational cost of Rs.4,714.00 ha\(^{-1}\), the total out put value was Rs.9,040 ha\(^{-1}\) including Rs.4840.00 ha\(^{-1}\) from paddy and Rs.4200.00 ha\(^{-1}\) from fish showing a net profit of Rs.4326.00 ha\(^{-1}\) (Tripathi, 1993). If no trenches were dug for fish, the income from two crops of paddy alone from the canal area would have been worth Rs. 1306.00 ha-1 as against the value of fish worth Rs.4200.00 ha-1 (Ghosh, 1979).

In organized system of coastal-fish culture system with distinct brackishwater and freshwater aquaculture phases the return to investment is 35 per cent where annual investment was Rs.22,555.00 ha\(^{-1}\) for a gross return of Rs.30,454 ha\(^{-1}\) on the basis of 1985 price index. The economic analysis of modified Bhasabada-type of rice-fish culture system in West Bengal revealed that an annual profit of Rs.21,755.00 was achieved against a total annual investment of Rs.38,645.00 where return to investment was 56.29 percent (Ghosh, 1990).

Ranadhir (1998) worked out an additional net income of Rs. 17,000.00 ha-1 in fish-cum-cattle farming where operational cost was estimated at Rs.5,400.00. The excreta from 3-4 pigs is sufficient to fertilize a small pond of size about 0.1 ha, earning an additional income of Rs.3,000.00 whereas, 40-50 ducks are sufficient to fertilize 0.1 ha pond and giving a net income of / Rs.4,650.00. A technology of raising 50 country poultry will provide sufficient manure to fertilize a pond of 0.1 ha and a
net income of Rs.4,000.00-5,000.00. The releasing of 5,000 fingerlings ha\(^{-1}\) of magur \((Clarias batrachus)\) fingerling in the paddy field can give an additional fish crop of 350 kg and net income of about Rs.6,000 ha\(^{-1}\).

The average of total fish production of 155, 73 and 11 kg ha\(^{-1}\) for rice-introduced fish, rice-indigenous fish and rice-monoculture was reported by Nhan \textit{et al.} (1997) in rice-fish farming in Mekong Delta in Vietnam. The study revealed that total farm return above variable costs (RAVC) and total farm net return (NR) of the rice introduced fish and the rice-indigenous fish systems are lower than those of the rice-monoculture system. The total farm cash return from rice introduced fish, rice indigenous fish, rice-monoculture were Rs.3,243.00, Rs.3,180.00 and Rs.3,914.00 per ha respectively.

Raju and Reddy (1998) reported that integrated farming system of rice-cum-fish culture is more suitable for small and marginal farmers. Experiment conducted on Rice-fish Farming at the Agricultural Research Station of West Godavari district in Andhra Pradesh revealed that paddy cultivation gave a net profit of Rs.6,000.00 to Rs.8,000.00 ha\(^{-1}\) yr ha\(^{-1}\) only, whereas under rice-fish and banana farming a net profit of about Rs. 18,000.00 to Rs.23,000.00 ha\(^{-1}\) yr ha\(^{-1}\) was obtained. The cultured fish species were catla, rohu, mrigal, common carp and \textit{Macrobrachium rosenbergii}.

Shingare and Shirgur (2000) reported that paddy-cum fish culture in summer yielded a production of an average of 140 kg of fish per hectare in a duration of 80 to 90 days. The yield of paddy went up by 38 per cent in the paddy plot with fish culture than in case of the plot with paddy culture alone. An appraisal of the economics of the trial operation revealed a net profit of around Rs.3103.00 through the sale of common carp.

Mealy and Dillon (1991) stated that the production function would explain the relationship between the input of factor services and output of the product. Samuelson (1973) defined production function as the maximum amount that could be produced by each and every set of specified inputs as factors of production. Strigler (1974) defined production as the relationship between inputs of production services and output of production per unit time. Sadeghi (1978) used Cobb Douglas type of
production function to study the impact of increased water supply on small farmers and concluded that small farmers were rational in the allocation of resources.

Reddy (1982) defined production function as the locus of efficient points of feasible production set and indicated quantitative relationship indicating maximum amount of physical product obtainable with in a set of inputs at a given technology.

Rout (1991) used six independent variables like mohua oil cake, lime, cowdung, fertilizer, feed and area to form a multiple regression model.

Ranadhir and Tripathi (1992) used Cobb-Douglas production function to find out the statistical relationship of physical quantities of inputs and outputs in fisheries. In the present study a linear form of production function was fitted to examine input and output relationship in fish farming system.

Rao and Raju (1997) studied efficiency of resource use in freshwater fish culture using Cobb-Douglas production function model where independent variables like pond area, stocking density, fertilizers, fed, fuel and electricity, pest and disease control, labour and capital service were used against dependent variable fish output in kg. This study revealed that fertilizers, pest and disease control measures and labour were found nonsignificant.

Marketing costs include preservation, processing, storage, transportation, commission and waste. Lack of efficient method of preservation, poor transportation and marketing facilities decrease farm prices as they result in poor quality and excess supply. With government support for improved transportation, storage and ice-plants, marketing cost can be substantially reduced. The development of co-operatives or associations would be also helpful to reduce marketing costs and to increase the marketing efficiency (Shang, 1981; Sathiadhas, 1997).

2.3 Fish Marketing Aspect

Marketing is process which starts with the decision to produce a saleable farm commodity and it involves all aspects of market structure or system, both functional
and institutional, based on technical and economic considerations and includes pre-
harvest and post-harvest operations, assembly, grading, storage and transport.

The importance of aquaculture to rural development is situational. The feasibility of aquaculture development efforts depends on local marketing conditions and marketability, which depends on the consumer preference and social attributes. Market prices of fish may be insufficient to stimulate farmers to invest in aquaculture. Thus, unless the fish can be marketed at a reasonable price, farmers are unlikely to invest in aquaculture.

Marketing function can be defined as a major specialized activity performed in accomplishing the marketing process. The important five marketing functions involved in the fish marketing process are preservation, transportation, facilitating, risk bearing and financing function. Intermediaries involved in the fish marketing system in Sri-Lanka were grouped as fish assemblers, fish wholesalers and fish retailers (Singhe, 1995).

The marketing systems for fish and prawn are explained in terms of use flows, physical flows, channel flows and farmer's share in consumers rupee (Kulkarni and Srivastava, 1985). The production from freshwater aquaculture is largely consumed in fresh form. The physical flows indicated that about 78 per cent of the aquaculture production is consumed in rural areas and the remaining 22 per cent in urban centres. For the transportation of fish bamboo baskets were used as packing material. The retailer was the most prominent market intermediary followed by significant intermediaries like wholesaler, commission agent and vendor. The least important intermediaries were pre-harvest contractors, wholesaler-cum-retailer, contractor-cum-wholesaler and co-operative society. The farmer's share in the consumers rupee was observed between 66.1 and 79.3 per cent for one member channel in direct sale through retailers. The average share of the farmer in more than one member channel was 61.3 per cent with the lowest at 36.5 per cent and highest at 69.6 per cent. In pond and tank aquaculture the farmer's share in the consumer rupee was high but the consumer price of fish was very low.

There are 12 market intermediaries and fish flow takes place through various combination of the intermediaries like pre-harvest contractor, contractor-cum-
wholesaler-cum-retailer, co-operative society, commission agent, commission agent-cum-wholesaler, wholesaler, wholesaler-cum-retailer, worker-cum-retailer, worker-cum-vender, retailer and vendor. Marketing is the most essential and important link in the success of aquaculture, but it is the most neglected activity today. Remunerative price for the producer and reasonable price for the consumer can be assured only by strengthening the fish marketing structure (Srivastava, 1992).

In Indian fish markets, the fishes are normally sold by auction system. In this system the auctioneer does not dispose of the fish until the highest bid price is reached. This type of auction system is followed in Crawford Market, Mumbai and some other parts of India whereas 'Dutch' method of auction system is followed in Kakinada, Andhra Pradesh and in some parts of Calcutta. In "Dutch" method, the auctioneer commences with a very high price and stops shouting when a buyer comes forward to purchase the fish at a lower bid. The best quality fish generally obtain better price by adopting auction method. No weighing and grading methods are practised in a large number of fish markets. The cultured fish in most cases is sorted out species-wise and also size-wise packed with ice, kept in bamboo baskets or wooden boxes and dispatched to distant markets. These activities are performed by the dalals on behalf of wholesalers or commission agent. In some cases primary co-operative society directly consigns the fish to the private trader. By the time fish reaches the consumer, it is handled by five or six middlemen, if the market is far away from the production centre (Rao, 1991).

Increased commercialization and pressure on the resource base has resulted in greater emphasis on higher value fish marketing than the traditional processed products which fishing communities were obliged to produce when marketing opportunities were fewer. A well organized and motivated fisherman groups in southern India have been very successful in obtaining a higher export price (Gordon, 1997).

Improved understanding of the market is important in predicting economic effects of changing consumption, production, and production innovations and assisting better management of marine resources. Marine and aquaculture production
are related through production of potentially substitute products for consumer markets. Product market factors that appear to be important in determining the relative success of an aquaculture species include the price of related species, the potential size of the market (numbers of the potential consumers) and particular characteristics of consumer tastes for product form and quality of a given species related to other species (Easley, 1992).

Freshwater fisheries sector totally lack the necessary infrastructure facilities like cold storage's, good approachable roads from farm sites to marketing centres for quick transport. The fish markets are controlled by powerful groups of middlemen who buy from the producers at prices which generally average about one third of the price paid by the consumer. Organized arrangements for storage and marketing of fish are necessary, and would be helpful in stabilizing price structure to benefit both the producer and consumer. Efficient co-operative marketing organizations may minimize and ultimately do away the vicious circle of the middlemen (Sinha and Ranadhir, 1980).

Lack of marketing facilities such as organized fish markets, market sheds or auction platforms, fish curing yards, availability of ice, salt, storage place, transportation, dependence on money-lenders and middlemen for credit and disposal of catches are the main factors leading to the exploitation of the fish farmers. The absence of institutional finance along with the above factors, put them in a precarious position involving a lot of strenuous work and heavy expenditure leaving marginal returns (Rao, 1995).

In most fishing communities of Asia and Africa, women have the primary and often exclusive responsibility for marketing fish and fishery products. This success of women in marketing depends on many factors like price level of competition, distance to market outlets, preservation of fish (Anon, 1997b).

Under conditions of imperfect competition, which include monopoly, oligopsony and monopsonic competition, pure profit is expected to be positive in long
run equilibrium and it can't be explained wholly in terms of the opportunity costs of the services provided by the middlemen (Sathiadhas, 1997).

The fish marketing in India is yet to develop on sound and modern structure. It is bounded by traditional paraphernalia and lacks by and large modern techniques of management despite some changes occurred in many fishery sectors (Rao, 1973). Fisheries co-operative have miserably failed to intervene in fish marketing and ensure a better consumer price to fishermen. The failure is considered to be one of the main reasons for the low incomes of fishermen. In order to extricate fishermen from the clutches of money lenders, it is necessary to confer the right for first sale of fish on bonafide fishermen through enactment of an appropriate fishery registration. The local bodies can also intervene effectively in a number of areas of marketing improve the present situation (Velayudhan, 1999).

2.4 Socio-economic Aspects of Fisheries

In fisheries, 'social' can be defined as a relation to the interaction of human beings with each other, as individuals or as groups. Economics is one form of interaction between people, and is therefore regarded as one of the 'social' sciences. Socio-economics is particularly common combination encountered in the field of planning and development work. Socio-economics has been brought into existence by the demands of planners attempting to combine coverage of the social sphere into one role with in the project or planning team. Sociologists must include economic factors in their analysis of development issues, and economists clearly need to take sociological factors into account (Townsley, 1998). Panayotou (1985) defined socio-economics as the amalgamation of sociology and economics.

The social science research in Asian aquaculture has been mostly on socio-economic aspects and there have been very few studies on the subject. Socio-economic studies begin with a detailed description of the socio-demographic characteristics of the sample (or population) under study. Factors such as family size, age structure, religious beliefs and educational attainment are among the variables which are considered for socio-economic study. Some studies use supplementary or alternative indicators of living such as food expenditure as a percentage of total
consumption expenditures, nutritional status, acquisition of consumer durable, educational levels and other quality of life variables. Public services, social amenities and community life may also be considered.

In the fisheries sector, several micro and macro level socio-economic surveys had been conducted by various agencies and research workers in different regions of our country to study one or the other problems of the fishermen community (Desai and Baichwal, 1960; Sen, 1973; Prakasam, 1974; George, 1974; Amarasini Desilva, 1977; Lawson, 1977; Panikkar, 1980; Sathiadhas and Venkatraman, 1981; Shambhu Dayal, 1973; Prasad Rao and Kumar, 1984; Subba Rao, 1986; Sathiadhas and Panikkar, 1988).

Proper incorporation of social issues into the process of policy making, formulating strategies and designing interventions for fisheries will inevitably require an increase in the number of social scientists involved in fisheries. In practical terms, sociological analysis in fisheries can be focused on a five key levels like gender, age, community, household and production unit (Townsley, 1998). These levels can be used to provide a basic framework to sociological analysis for fisheries. These five elements can generally be considered the 'building blocks' of most social systems throughout the world so an understanding of how they are constituted and their significance is fundamental.

Gender issues are concerned with complex of social, economic and cultural factors, which distinguish men from women. Development agencies throughout the world are mostly run by men but much of the productive work in many societies is carried out by women. The consideration of gender issues is a key element in the analysis of any fisheries system.

The community is often the most convenient administrative level at which to implement activities in the field. It is often assumed that people living within certain administrative boundaries, or living in close proximity to one another automatically constitute a community, which has certain common interests, goals and a communal sense of identity. Age is an issue which can not be approached with cultural
preconceptions about what the roles and need of specific age groups might be. A better understanding of the role of age in determining levels of economic and social participation may be of great importance when it comes to targeting interventions. Considerable attention is to be given regarding what constitutes a household in different social and cultural context. Household level analysis is of great importance in understanding how plans will affect people at the grass-root level.

In fisheries as in many other countries, production frequently brings together groups of people not necessarily related or linked in other ways, such as by kinship or community. The production unit may therefore be the focus for a whole new set of social, cultural and economic dynamics, which need to be part of any sociological analysis (Dixitulu, 1990).

Social taboos among fishermen communities have deeply penetrated and it is not an easy task for developmental planners to change them over to modern scientific methods early. The best way to convince them is by showing them the actual practices in their ponds successfully (Sinha and Ranadhir, 1980).

Fishermen engaged in their traditional occupation whether in the coastal or inland areas happen to be in the bottom of the social and economic pyramid. So integrated rural development, which can improve the economic condition of the fishermen, should go a long way towards achieving the national developmental goals. Achievement of these goals will require the development and extension of appropriate technologies, the setting up of efficient organisational network and the development of marketing procedures and processing methods to look after the post-harvest technology. The laboratory to field network should be strengthened by the creation of a good extension service as well as through establishing links with banks for the supply of credit (Anon, 1986).

Socio-economic parameters such as family size, age structure, customs, beliefs and habits, employment potentials and education and living standards of fishermen influence their response to new technology and their participation in development schemes. Studies on these variables attempt not only to explain the overall socio-
economic conditions of the fishermen but also identify the factors constraining the
realisation of full potential of traditional fishery and the appropriate area on
government intervention (Sathiadhas and Panikkar, 1988).

Siddiqui (1996) conducted a study of socio-economic problems of the
fishermen in Tamilnadu and Orissa where their caste and language, age distribution,
marital status, household size, literacy rate, location, livelihood, insurance, source of
funding, marketing facilities, expenditure and indebtedness were studied. Studies
revealed that socio-economic condition of the traditional fishermen were far from
satisfactory on account of lack of infrastructure and communication facilities. Efforts
are required to provide basic infrastructure facilities like *pucca* roads, drinking water
supply, sanitation facilities, transportation, schools and medical facilities etc.

Cheng and Capps (1988) observed some demographic variables, which
significantly affect expenditures on some species of fish or shellfish, were region of
the country, urbanization, occupation of head of household presence of children, race
and season.

The worsening problem of inequity in fisheries shifted the concern to the
socio-economic issues of sustainability and equity in Philippines. Research gaps and
researchable areas were determined to identify future research directions in a study on
socio-economic research in the Philippine fishery sector (Anon, 1992).

In the fishery sector, adoption of technological innovations and enhancement
of fishery infrastructure facilities have been supported by government. In spite of
encouragement of government, for co-operative and banking facilities, most of the
fishermen are still in the grip of poverty. In this context, status of fishermen pertaining
to different regions of the country will be immensely useful for future planning of
developmental schemes (Sehera *et al.*, 1988).

Choudhury (1989) analysed econometrically the socio-economic conditions of
fishermen community in two districts of lower Assam. The studies revealed that
income and family size were directly correlated. Family size, expenditure on food,
cloth and fuel were reported to have direct bearing on the total monthly expenditure of fishermen households.

Easley (1992) reported some socio-demographic changes under way in the United States that may affect future demand for fishery products and some that may affect aquaculture products specifically. The apparent increasing interest in knowledge of, the nutritional content of alternative foods, the aging of the US population and growth in female labour-force participation are the socio-demographic changes underway in US.

In fisheries sector, socio-economic status of fishermen plays a key role in productive activities. No one has time to listen, appreciate and assess the severity or magnitude of their personal, profession and other related problems. These are responsible for age-old backwardness and poor performance of the fishermen, both as individual and as human resources. Singh et al. (1995) studied the social status and socio-economic problems of fishermen living along the Ganga and the Yamuna at Allahabad. The study revealed that the fishermen were highly indebted to fish marketing intermediaries and betrayed of remunerative returns for their catch. Their socio-economic status was very poor which needs an in-depth study.

Studies revealed that majority of the fishing villages were situated on the banks of rivers, estuaries, lakes etc. far away from urban and industrial centres and other rural villages isolating themselves geographically and socially from the main stream of national life. Due to lack of proper transportation and communication facilities, the fisherfolk had little contact with outside world. Hence their problems fail to receive sufficient attention from the local authorities (Rao, 1995).

Fish farmers, artisanal fishermen and fisherwomen engaged in fish culture, collection of fish seed from natural resources, fishing in closed and open inland and coastal waters, processing, transport and marketing of the fishery products etc. are the primary producers of the sector and as such they are the focal object for sectoral development and welfare schemes. Unlike agriculture, there is marked socio-economic and functional stratification among the primary producers. They are divided into small scale aquaculturists belonging to landless / pondless marginal farmer category, the artisanal fishermen and fisherwomen engaged in fishing, transport,
crude processing and retail marketing of fishery products, and the last group consisting of affluent and well-off aquaculture entrepreneurs, corporate bodies, trading houses etc (Kumar, 1996).

The traditional fishers operating in the inshore regions are caught in a low-income trap due to diminishing returns from capture fisheries. Hence, integration of small-scale mariculture with small-scale capture fisheries is a viable alternative to supplement their income (Sathiadhas, 1996). This integrative approach can also be tried for the economic development of the inland fisher-folk.

Fish culture is liable to be affected by pollution, disease, flood, inadequate water supply, predation, etc. most of these are because of management failures, but others are purely socio-economical. These aspects need proper understanding (Sinha and Ramachandran, 1998).

Fisheries in wider term have global economic importance. In India it is all the more important as it has religious, social and commercial values. Fisheries has the potential and capacity to become a giant industry so as to create significant impact on socio-economic status of countrymen who are the nucleus of all the economic activities. This objective is already spelt out in Ninth Plan document when it states that in a development of fisheries with bio-physical processes at the expense of social process would be detrimental to the over all progress. Considering this, it is but natural to expect that the benefits of various development projects should reach the fishermen and fish farmers (Pathak, 1998).

Socio-economic milieu under which the inland fishers / fish farmers operate is not conducive enough to attract credit and infrastructure support for required aquaculture inputs as well as modem craft and gear from traditional banking and financial institutions. The migratory character, seasonality of fishing activities, unstable catch composition of inland fisheries and economic status resulting in lack of credit worthiness of inland fisheries / fish farmers does adversely affect investment appraisal and assessment of funding possibilities. There is an inescapable need to evolve some distinct criteria for financing the inland fisheries. This would need evolving a new set of criteria for assessing credit - worthiness and repaying capacity of inland fishers / fish farmers (Sinha, 1999).
The need for raising the socio-economic status of people above poverty level is an urgent need in our country and effort are focused on identifying technology which can help in this direction. The socio-economic status of aquaculture has been studied by many workers (Nengu and Nitsene, 1988; Lemna and Angwazi, 1988; Corvert 1988). The socioeconomics of aquaculture development in India indicated that the pond resource is generally not available to the fishermen or the fish farmer with the lack of credit facility at reasonable rates of interest.

Dutta (1998) assessed the state of fish culture development and the socio-economic conditions of the fish farming families which may have an impact in determining the present level of fish culture development in Assam. The studies revealed that 75 per cent of people of fish farming families were literate and for 80 per cent of them primary occupation was agriculture. Average annual household income of the fish farming families had been estimated at Rs. 10,020.00. in which contribution from agriculture, livestock, fishery and horticultural crop were 44 per cent, 19 per cent, 17 per cent and 12 per cent respectively.

Rout and Das (1992) studied on the socio-economic aspects of extensive shrimp aquaculture in Ganjam district of Orissa and revealed that capital was scarce in the rural areas. So knowledge and skill of brackish water prawn farming should substitute the capital of villagers.

Poaching became a serious problem for fish culture throughout India, especially in the eastern part of the country where fish is in great demand. Besides employing watchmen, perhaps it may be helpful if bushy plant materials are kept inside ponds to prevent easy netting (Sinha and Ranadhir, 1980).

Samonte, 1992 studied socio-economics of oyster and mussel farming in Philippines using a combination of rapid rural appraisal techniques and a semi-structured questionnaire. The socio-economic condition of oyster and mussel farmers were described in their studies. The development of oyster farming would be sustained by providing appropriate management policies.
A socio-economic study of Tilapia culture in seasonal ponds in Bangladesh indicated that it improved the nutrition of farming families. Revenue obtained from 28 per cent of fish and fingerlings sold was enough to meet the operational costs and this makes the operations sustainable. In addition to economic returns, the implementation of the technology resulted in social benefits to farmers, in that they were able to present fish to their neighbours, resulting in better relationship. Also, some farmers could pay for the education of their children through income generated from the operation (Gupta et al., 1992).

Unlike the magnitude of extension efforts of the government agencies in technology transfer in the agriculture sector, it is inadequate in case of fishery, furthermore the modicum efforts made so far are non convincing for acceptance of the fish farmers. A concerted effort on farm practical training in carp polyculture to potential fish farmers; literature support in local language; exposure through communication media and institutional funding support through government departments is considered essential to bring adequate impact on the socio-economic status of fish farming families, by adoption of scientific methodologies of carp polyculture (Dutta et al., 1979).

Mahandra Kumar, 1996 reported that age was not a significant factor in composite fish culture practices. Sheela (1996) reported that age was not found to be significant in sea weed collection and cultivation by fishers. Age was also found non-significant in poultry technology (Nimji et al., 1992), dry farming practices (Manjunath et al., 1996) dry land agricultural technologies (Prasad, and Sundarswamy, 1999) etc. where as age was found to be negatively significant in paddy seed production practices (Pattnayak, 1996), fishing (Jagatap, 1997), dairy practicing by women (Sheela and Sundaraswamy, 1999).

Education is an important socio-economic factor which has lot of bearings on fish farming technology. The studies revealed that education was positively and significantly co-related with composite fish culture (Mahandra Kumar, 1996), seaweed collection and cultivation by fishers (Sheela, 1996), fishing (Jagtap, 1997).
Mahandra Kumar (1996) reported that experience was negatively significant in composite fish culture practices but positively co-related with paddy seed production (Pattnayak, 1996), seaweed collection and cultivation by fishers. (Sheela, 1996).

In most of the cases total annual income and social participation show positive significance in farming practices. Total annual income was positively significant in composite fish culture (Mahandra Kumar, 1996), farm implementation (Sontakki, 1989), buffalo husbandry practices (Thangavel et al., 1996) where as total annual income had negative significance in dairy practicing by women (Sheela and Sundarswamy, 1999). Social participation showed positive significance in farm mechanization (Singh, 1983), farm implementation (Sontakki, 1989), composite fish culture (Mahandra Kumar, 1996).

2.5 Role of Women in Fisheries

The basic goal for women in fisheries development is to make them equal partners, productive and self reliant participants in the process of improving their own and their family's nutritional and living standard and to enable them to realize their full potential as human beings in their own right and as members of their family and community.

A landmark seminar on "Women in Fisheries in Indo-China countries, 6-8 March, 1996 in Phnompenh, Cambodia, examines the status of women in the fisheries sector and spells out recommendations for future action to further enhance the role of women. Apart from their contribution to traditional sectors like aquaculture, their participation in fisheries research, education and extension is highly emphasized. A holistic approach for gender balanced programme for rapid development is essential.

As in agriculture, participation of women in fishery is gradually gaining momentum, research and training programmes for them are now being planned and executed. But such programmes can be made successful only if these are based on facts and realities (Sadangi et al., 1999).
The 'technologicalisation' and intensification of production has often led to a decrease in the participation of women. Even in areas where aquaculture is promoted as a novel supplement to any or alternative livelihood strategy. Women are commonly excluded from management and decision making. Extension efforts are mostly directed at men (Felsing et al., 2000).

The various economic activities in which the women of the fishing villages participated were grouped as fishery based and non-fishery based. The fishery based includes fisheries and aquaculture whereas non-fishery based comprised of agricultural work and other miscellaneous activities. Women-folk participated in shore based activities like fish handling, processing, preservation (drying and curing of fish), distribution and marketing, net making, seashell collection, etc. besides their routine domestic chores and occasional participation in non-fishery based activities. The women belonging to prosperous category of households do not participate in fish marketing or any other fishery or non-fishery based activities. The women belonging of less prosperous category participate in all activities related to fishery and non-fishery (Rao, 1995).

Owing to the nature of various tasks involved in fisheries, men and women tend to undertake different tasks. In aquaculture, men dig the ponds and play an active role in pond preparation. While women become more active in post stocking operations like fertilization and daily feeding of fish. These division of labour are not fixed and absolute, but they vary from area to area and also over a period of time. Many aspects of women in fisheries are related to the creation of household food security i.e. the sustainable supply of and access to food (Nandeesh, 1996).

Sharma et al. (1988) reported that Small backyard ponds are also ideally suited for rearing carp seed by Women. The manufacture of fishing nets, fish traps and baskets for fresh fish transportation can be taken up by women as a cottage industry. Once trained women, could earn more from net fabrication than from agricultural activities (Radheyshyam et al., 1986).

Gupta and Rab (1994) stated that women could participate in aquaculture in Bangladesh, without diverting the efforts of men, which could be in agriculture.
Women introduced in aquaculture were seen to stock fingerlings of silver barb (Puntius gonionotus) using lime and rice-bran and involved in harvesting.

Kvam (1987) reported that both men and women actively participated in production activities in Thailand. He observed several instances of women's group engaged in aquaculture activities. They are often better than men as they do not leave the village on labour migration as often like the men. Further, they have more experience in income generating activities.

In capture fisheries most of the works are carried out by men, particularly in the commercial sector and the concerns of women in fisheries are easily ignored. Women dominate many key sub sectors in fisheries. Small-scale fishing and collection of other foods found in water may be carried out by women and constitute an important source of household food supply. Women predominantly carry out marketing and processing in both the artisanal and the industrial sectors in many parts of the world. In West Africa, the central role played by women in the handling of fish catches extends to the financing of artisanal fishing companies (Townsley, 1998).

The role of women in fisheries in the production, processing or marketing is not always adequately recognized. Women's contribution to increase aquaculture production especially in Asia where they form the major share in population, has largely gone unnoticed. On the other hand, most fishing and fish processing nations are conspicuous in limited representation of women in fishery management and policy formulating process (Anon, 1999).

At subsistence level, aquaculture can provide animal protein food and cash income to the family. Aquaculture in homestead family ponds is also developing as a family farming in Vietnam where women play a big role and earn better benefits (Luu, 1999).

Aquaculture is the emerging potential sector where women can benefit from the technology leading to their empowerment and contribution to the development of fisheries (Bhanot et al., 1998). Rural women are engaged in a host of activities in the freshwater culture practices, contributing to the production systems. These include
aquatic weed management and culture of commercially important macrophytes like Makhana, pond fertilization, fish seed rearing and integrated fish farming.

Fish retailing is mainly women's domain all over the country, both in the inland and marine sectors. In the coastal belts, after the fish haul, fisher-women lend a big hand in sorting, grading, processing etc and constitute a substantial work force in the export oriented marine products processing units. In aquaculture, the regular application of supplementary feeds, manuring, intermittent checking of water quality etc. can very well be attended by the women members. These additional components of fish cultural husbandry can augment fish production from rural ponds, thereby helping substantially to the rural economy (Banerji, 1993).

The potential areas where women can play important role are ornamental fish breeding and culture, catfish and prawn breeding, freshwater pearl culture, spirulina cultivation, production of bio-fertilizers like Azolla, net making and mending, preparation of feeds. In brackishwater sector women have played important roles by participating in both natural collection of seed and induced breeding. Women have also participated in traditional prawn rearing for short duration in Pokkali fields of Kerala. Of late, their involvement has also been appreciable in scientific prawn farming practice in terms of seed collection or production, pond preparation, stocking, manuring and post-harvest operations. New technologies of mariculture like seaweed culture, edible oyster culture, mussel culture, pearl culture provide new avenues for women enterprises (Dube, 1999).

Fisher-women can improve their economic lot by joining co-operative movement. If co-operative movement is to succeed, it is absolutely necessary and important that the women are involved and made to play a very positive and active role in implementing the programmes (Anon, 1988).

Varghese and Nandeesha (1992) suggested a few avenues for increasing the employment opportunities for rural women through small-scale aquaculture units. A characteristic feature of rural West Bengal, Orissa and Assam is that most houses have small backyard ponds, or a ditch. The women members of the family can easily
go for fish cultivation in that ponds. They can periodically fertilize the ponds with cowdung and feed the fish by dumping all the spoiled food, left over and kitchen refuse. Under this kind of fish culture it is possible to get a production of about 100 kg annually from a pond of 200 m².

Women in fishing communities have decision-making role in community management. With the increasing commercialization of fishing industry, women's access to post-harvest operations in fisheries ha; been declining. It is estimated that only about 20 per cent of women from traditional fishing house-holds get opportunities for income generation from fishery related activities which are seasonal. As a result of marginalization and lack of alternatives and also the irregularity of income from fishing, women in traditional fishing communities are adversely affected (Srinath et al., 1994). It was reported that income generation through on-farm feed production by women was considered to be very appropriate. The creation of awareness on financial support was crucial as people are often misguided by local advises.

Rao (1995) studied the status and role of women in fishing communities in India. The study revealed that the women are totally uneducated and imbued feelings of religious and superstitious beliefs. There is no gainful employment either in fisheries or outside for majority of women. They could not avail the opportunities in modem fishing to their best advantage due to the absence of proper skills and training. Poverty, landless and other economic factors along with Socio-cultural factors influence the women to participate in earning process (Anon, 1981).

2.6 Knowledge

The common assumption of knowledge means the sum total of what is known, the whole body of truth, fact, information, principles, or other objects of cognition required by mankind. Bloom et al. (1956) defined knowledge which involves the recall of specific and universals, the recall methods and procedures or the recall of a pattern, structure or setting.
Rogers and Shoemaker (1971) stated knowledge as a function or a stage of the decision process when "the individual is exposed to an innovation's existence or gains some understanding of how it functions". Knowledge is the totality of understood information processed by a person.

Knowledge means knowing about something, which contain an element of the concept insight (Ban and Hawkins, 1988) knowledge is to be considered the vision of an explanation for the world in which we live, knowledge is relative in the sense that the vision can differ between people among others because of differences in experience.

A nation's ability to convert knowledge into wealth and social good through the process of innovation is going to determine its future. The power of knowledge in the knowledge society is there for all of us to see. To meet the twin objectives of growth with equity, knowledge can't be the prerogative of a few, every one in the society must have access to knowledge and become a knowledge worker. It is not scientists and technologists alone, who will be knowledge workers. Even a farmer can be a knowledge worker provided he understands the soil he is sowing his seeds in, he understands why and how of the micro-nutrient and pesticide addition that he makes, he lives in an information village, where he has the benefit of short and medium range weather forecasting to plan his farming activity and so on. If he does so, then he will be a continuous user of knowledge and he will be a knowledge worker (Mashelkar, 1999).

Knowledge on the role of important independent variables in acceptance or rejection of technological innovation by farmer is prerequisite in extension programme formulation (Das et al., 1988).

In fisheries, there are at least four reasons for researchers, development workers and policy makers attempting to understand the indigenous knowledge shared by a particular community. First, indigenous knowledge constitutes a community's adaptation to its environment. Second, solution to problems in fisheries lie outside the sector. This assertion underscores the necessity of understanding the complexities of a
fishing community before any intervention designed to uplift its standard of living is recommended and implemented (Smith, 1981). Third, with in the context of a common property resource like fishery, it is important to identify the different groups that have stakes in changes that could occur in institutional arrangements and access to the resources (Ruddle, 1988). Finally fisheries management would benefit from the fishers time tested practices.

Seenapa and Surendra (1988) revealed that training has influenced the participants to gain more information about fish culture, its economic feasibility and profitability. The increase in favourable attitude of trainees noticed after the training could be attributed to the imparting of knowledge regarding various facilities such as leasing of tanks, supplying of quality fish seed, subsidies on the inputs and financial assistance. The resultant high level of gain in over all knowledge may be due to the strong desire of participants to adopt new practices to get high yield. The correlation values indicated a negative relationship between age and knowledge, education and attitude and landholding and attitude. A significant positive relationship was found only between landholding and knowledge before the training and between age and attitude after the training.

Sharma and Nair (1974) reported that knowledge was positively and significantly related with the adoption of high yielding varieties of paddy.

Sanoria and Singh (1978) found that level of knowledge of farmers regarding the improved practices was a significant factor affecting the adoption of improved practices.

2.7 Adoption

Technological advance in aquaculture envisages through continuous research and by transfer of technology to fish farmers. Even when improved technology is available, expected aquaculture production could be achieved only when there is no gap between the recommendation and adoption (Suresh et al., 1988)
Research investigations on technology generation in India during the last decades have laid the strong foundation of scientific fish farming with promise of high economic returns. With this background of technological innovations, effective extension service for the desired fisheries development is the present requirement in the country (Natarajan, 1982).

The success of fish culture depends to a great extent on the adoption of proven new technology evolved for the purpose of obtaining higher yields and return. Adequate information about any new farming practice and interaction complements to bring about desirable change in human behavior in any programme of planned change (Haque and Ray, 1983).

Vasanthakumar (1988) studied the information seeking behavior of traditional fishermen to measure the extent of adoption of improved technology and to identify the problems limiting adoption of improved technology by traditional fishermen of Chidambaranar district, Tamil Nadu. Technique of pond management such as stocking, feeding, fertilizing harvesting etc. should be closely linked with need and interest of farmers through well planned extension methods. Active involvement of farmers with result oriented high yield demonstration programme should be adopted (Rout and Das, 1992).

Gupta and Rab (1994) studied the adoption and economics of silver barb Puntius gonionotus culture in seasonal waters in Bangladesh. The study revealed that rapid growth of P. goninotus, low investment and simple technology were perceived as the most important encouraging factors for the adoption of the technology, whereas non-availability of credits for inputs, inadequate supply of P. gonionotus fingerlings and small size of ponds, were conceived as constraints to expansion.

Das et al., (1988) carried out a study to find out the relationship of adoption of fish culture innovations with 14 selected independent variables like situational (total pond area, maximum and minimum water depth), socio- personnel (age and education of the fish farmers), socio-psychological (experience in traditional and improved fish culture) and communication (participation in training programme and fish farmers days, utilization of mass media, cosmopolite source of information and locality source of information). The findings revealed substantial positive contribution by the
variables 'minimum water area in ponds' in adoption of the technology of composite fish culture. Haque (1981) made similar observations in fishery extension. Studies conducted under Indian conditions in agriculture have shown that the size of the farm was positively and significantly associated with the adoption of farming practices (Sinha, 1978).

A negative relationship of the variable 'age of the fish farmers' with the adoption of composite fish culture was found in the study of Das et al., (1988). This showed that younger fish farmers are progressive while the older ones are conservative. Experience in improved fish culture in the study was observed to have strong positive relation with the adoption of composite fish culture. Positive contribution was made by training programmes followed by fish farmers days which are in lines with the observations in agriculture (Sinha, 1978) and animal husbandry (diary extension) (Sohi and Kherdar, 1980). Haque (1981) in fishery extension found that the use of 'mass media' and 'personnel cosmopolite' sources were positively and significantly associated with the adoption behavior of the farmers.

According to Siar et al. (1994) researchers, development workers and policy makers must understand the indigenous knowledge shared by a particular community. Indigenous knowledge constitutes a community's adoption to its environment. Adoption here means the way fisher folk harness the resources of their environment in order to establish a viable relationship to it (Jacano and Velor, 1976).

Gupta et al., (1996) undertook a study to assess the extent of adoption of integration of aquaculture with rice, factors contributing and limiting adoption, factors affecting farmers management decisions and the effects of rice fish farming on local farming systems and the families general welfare. The three stimuli encouraged farmer to take up the practices were motivation by extension workers, the experience of being involved in on farm research and direct observation of examples.

Bhaumik and Saha (1998) carried out investigations in some areas of west Bengal to know the level of adoption, extent of continuance of recommended package of practices, constraints as perceived by the fish farmers and its implications. The results indicated that the technology had been taken up by a particular group of fish farmers who could overcome most of the constraints. The study further revealed that
there was positive and significant relationship between adoption behavior and fish farmer's characteristics viz. education level, socio-economic status and contact with extension functionaries. Age and caste did not show any significant association with adoption. The problem faced by the farmers in adopting recommended package of practices were in the descending order due to high cost of input, poaching of fish, poisoning in the pond, high rent of water body, lack of follow-up action, marketing of harvested fish, non-availability of subsidy, non-availability of finance, multiple ownership of water body and stagnancy of capital.

Training of fish farmers on new fish culture practices has been recommended to induce motivation, create awareness and confidence and inculcate efficiency. The training can be more fruitful, if designed according to the participant's needs, which are based on the knowledge and attitude already possessed by them. Socio-economic factors viz. Age, education, land holding etc., may also play a role on the knowledge and attitude at adopters (Singh and Kunzroo, 1985 & Zhagon and Singh, 1986).